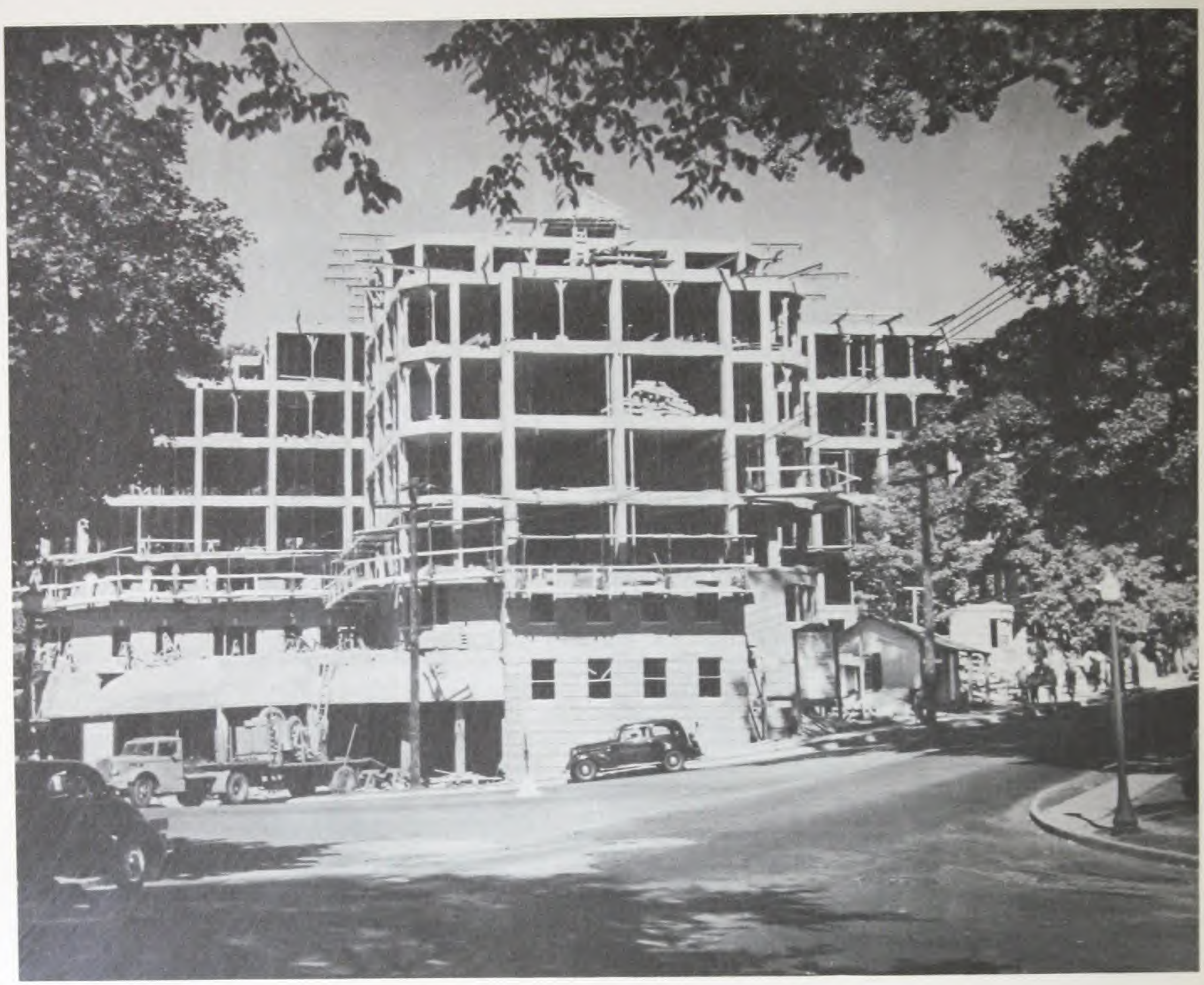
Cutting Concrete Costs

Building jobs which are rushed to completion have one thing in common with jobs where there is no pressure for fast work—in both cases, lowest construction costs result from the best use of time . . . How time affects frame erection costs, and how savings can readily be estimated in advance, is told in the following pages. These principles apply not only to buildings but to all structures on which there is an opportunity to re-use forms.



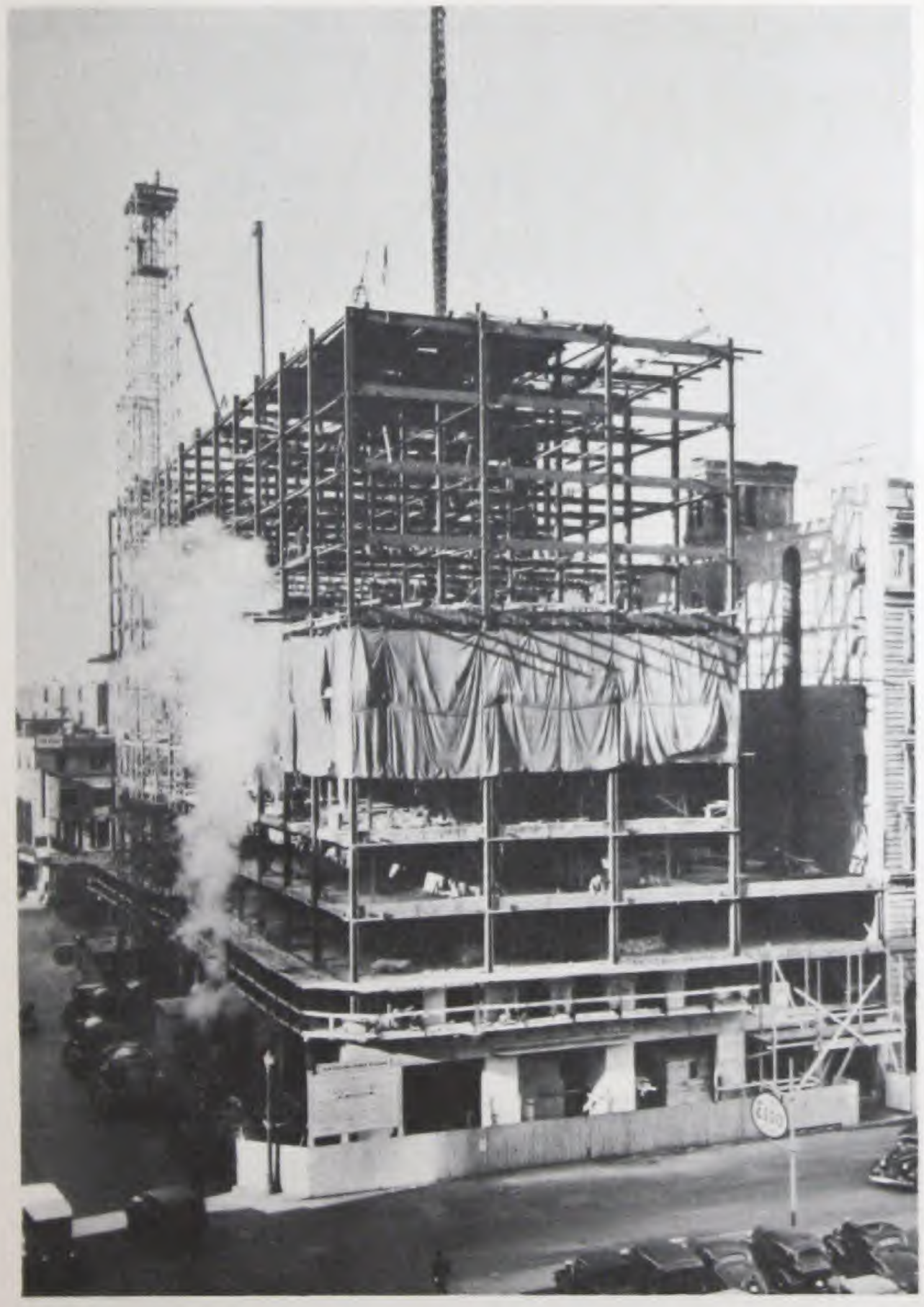
Popham Hall Apartments, Scarsdale, N. Y.

Here are two buildings, one a concrete skeleton frame apartment house (above), the other a steel-frame office building (at right). On one, the contractor was working against time—the apartment house had to be ready for early occupancy; on the office building, there was no pressure for early completion. Yet, on both jobs, cost studies showed that substantial net savings were realized, by utilizing erection schedules which made the best use of time. The rush job showed a net saving of $1.45 per cu. yd. of concrete; on the other job, the net saving was $1.49 per cu. yd. of concrete.

Taking Costs Apart

IT is a generally accepted fact that rush work increases building costs, due to overtime, confusion and lost motion. Yet, contractors' cost sheets show that many rush jobs have been completed at little or no extra cost, simply because faster construction schedules produced savings in frame erection which offset increased costs in subsequent operations. A number of questions immediately come to mind.

Why is it that rush jobs frequently show savings in frame-erection costs? Are similar savings possible on jobs where the contractor has no reason to push the work? Are these economies obtained only on concrete frame structures, or on steel-frame and wall-bearing jobs as well? How can the contractor find out in advance which erection schedule will produce the lowest concreting cost?



NEW ENGLAND POWER COMPANY BUILDING, BOSTON

WHAT COST STUDIES SHOW

Detailed cost studies now make it possible to answer these and related questions. These studies show that the frame is the only part of the building where time can be saved at no extra expense, and often at a substantial saving.

Thus, six recent jobs, analyzed in detail with the cooperation of the contractors, have shown *net* savings of from 38c to $1.49 a cubic yard of concrete, simply because the con-

tractors used erection schedules which produced the lowest *overall* cost of time, forms and cement.

HOW TIME AFFECTS COSTS

The reason is clear enough, when you stop to think about it:

Time obviously costs money, because the contractor's investment in organization, equipment and in his own skill and experience, represent fixed costs which run on steadily, from week to week and month to month.

This investment can only earn a return while actually working; idle time brings no income, yet outgo keeps up just the same. Therefore, the more work the contractor completes in a year, the lower the daily time cost charged against each job.

The same principle applies to the individual job; in fact, the difference between profit and loss frequently turns on this very point; shortening the time required to complete a job,

lowers the cost—provided, of course, that the value of the time saved exceeds the cost of saving it.

An analysis of concreting operations discloses the reasons.

ERECTION TIME ANALYZED

The time required to concrete a building divides into three parts:

(1) days required to assemble forms and set steel and conduits;

(2) days required for placing concrete;

(3) time elapsing until concrete is strong enough to permit removal of forms.

The contractor is paid for work in place, so the second or concreting period is the one that actually produces income. All other days are consumed getting ready to pour, or in waiting for concrete to become service strong, so that forms can be stripped and re-assembled for the next cycle of operations.

If time can be saved in the first and third periods, the total amount of income-producing work completed in a week or a month can be increased.

STRENGTH-GAINING TIME DECIDING COST FACTOR

The number of days in the first period, getting ready to pour, is pretty much fixed by job conditions; relatively little time can be saved there. But the length of the third or strength-gaining period can be increased or decreased, depending upon the kind and quantity of cement used in the mix. Examples:

A concrete made with 5 gal. of water per bag of cement gains strength faster and permits form removal sooner than an 8-gal. concrete.

Also, a concrete made with 'Incor' 24-Hour Cement hardens rapidly and permits form removal after one or two days; while Lone Star Cement, which hardens less rapidly, requires 3 to 7 days for service strengths.

Then, too, cold concrete hardens slower than warm; and concrete kept wet after placing gains strength faster than if allowed to dry out.

So, this third or strength-gaining period can be greatly reduced, or in fact eliminated, in

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Time required to concrete a building frame divides into three parts: (1) Form assembly; (2) placing concrete; (3) waiting for concrete to become self-supporting. Since the contractor is paid for work in place, the second or concrete-placing period is the one that actually produces income. Days saved in the form-assembly and strength-gaining periods shorten the interval between pours; hence, more income-producing work can be completed in a given time. While the first period is more or less fixed by job conditions, the third or strength-gaining period can be long or short, depending upon the quantity and type of cement used.

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so far as it affects job progress.

TWO WAYS TO REDUCE TIME BETWEEN POURS

Time between pours can be minimized, and output of income-producing work increased, by using a concrete which produces early strength. Similar results can be obtained by using a second set of forms. Which method to use depends upon the value of the time saved, as compared with the cost of saving it.

Tables I and II show how different strength-gaining periods affect total construction time in buildings of 2 to 16 stories. Forming schedules of 3 to 6 days per floor are shown, with strength-gaining periods of one day to two weeks.

EXAMPLE ILLUSTRATES USE OF TABLES I-II

If it takes five days to assemble forms, and the strength-gaining period is 7 days, total con-

The strength-gaining period's retarding effect upon job progress can be eliminated by using high early strength concrete, or a second set of forms. In either case, the time between pours is minimized and output of income-producing work increased. Which method to use depends upon the value of the time saved, as compared with the cost of saving it. This can be determined by a comparison of the overall cost of time, forms and cement.

Table I

Summary: Working days required for completion of concrete frame for different forming and curing schedules.

Days Forming	Days Form Removal	5-DAY WEEK														
		Workdays Required to Erect Frame of 2 to 16 Floors														
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 SET OF FORMS																
3	1	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64
4	1	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
5	1	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96
6	1	14	21	28	35	42	49	56	63	70	77	84	91	98	105	112
3	2	9	14	19	24	29	34	39	44	49	54	59	64	69	74	79
4	2	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
5	2	13	20	26	33	40	46	53	60	66	73	80	86	93	100	106
6	2	15	22	30	37	45	52	60	67	75	82	90	97	105	112	120
3	3	9	14	19	24	29	34	39	44	49	54	59	64	69	74	79
4	3	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
5	3	14	21	29	36	44	51	59	66	74	81	89	96	104	111	119
6	3	16	25	32	41	50	57	66	75	82	91	100	107	116	125	132
3	4	9	14	19	24	29	34	39	44	49	54	59	64	69	74	79
4	4	11	19	25	31	39	45	51	59	65	71	79	85	91	99	105
5	4	15	22	31	40	47	56	65	72	81	90	97	106	115	122	131
6	4	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157
3	5	10	16	24	30	36	44	50	56	64	70	76	84	90	96	104
4	5	12	20	27	35	42	50	57	65	72	80	87	95	102	110	117
5	5	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156
6	5	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157
3	7	12	20	28	36	44	52	60	68	76	84	92	100	108	116	124
4	7	14	23	32	41	50	59	68	77	86	95	104	113	122	131	140
5	7	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156
6	7	18	29	40	51	62	73	84	95	106	117	128	139	150	161	172
3	10	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154
4	10	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155
5	10	19	31	44	56	69	81	94	106	119	131	144	156	169	181	194
6	10	21	35	47	61	75	87	101	115	127	141	155	167	181	195	207
3	14	17	30	43	56	69	82	95	108	121	134	147	160	173	186	199
4	14	19	33	47	61	75	89	103	117	131	145	159	173	187	201	215
5	14	21	36	51	66	81	96	111	126	141	156	171	186	201	216	231
6	14	23	39	55	71	87	103	119	135	151	167	183	199	215	231	247
2 SETS OF FORMS																
3	7	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64
4	10	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
5	9	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96
6	10	14	21	28	35	42	49	56	63	70	77	84	91	98	105	112

Table II

Summary: Working days required for completion of concrete frame for different forming and curing schedules.

Days Forming	Days Form Removal	6-DAY WEEK														
		Workdays Required to Erect Frame of 2 to 16 Floors														
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1 SET OF FORMS																
3	1	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64
4	1	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
5	1	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96
6	1	14	21	28	35	42	49	56	63	70	77	84	91	98	105	112
3	2	9	14	19	24	28	33	38	43	48	52	57	62	67	72	76
4	2	11	17	23	29	35	41	47	53	59	65	71	77	83	89	95
5	2	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96
6	2	15	23	31	39	47	55	63	71	79	87	95	103	111	119	127
3	3	10	16	22	28	34	40	46	52	58	64	70	76	82	88	94
4	3	11	17	23	29	35	41	47	53	59	65	71	77	83	89	95
5	3	13	21	29	36	43	51	59	66	73	81	89	96	103	111	119
6	3	16	25	34	43	52	61	70	79	88	97	106	115	124	133	142
3	4	10	16	22	28	34	40	46	52	58	64	70	76	82	88	94
4	4	12	19	27	35	42	49	57	65	72	79	87	95	102	109	117
5	4	14	23	31	40	48	56	65	73	82	90	98	107	115	124	132
6	4	17	26	36	45	55	64	74	83	93	102	112	121	131	140	150
3	5	11	18	25	33	40	47	54	61	69	76	83	90	97	105	112
4	5	13	22	30	38	47	55	63	72	80	88	97	105	113	122	130
5	5	15	24	33	42	51	60	69	78	87	96	105	114	123	132	141
6	5	18	28	38	49	60	70	80	91	102	112	122	133	144	154	164
3	7	13	22	31	40	49	58	67	76	85	94	103	112	121	130	139
4	7	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155
5	7	17	28	39	50	61	72	83	94	105	116	127	138	149	160	171
6	7	19	31	43	55	67	79	91	103	115	127	139	151	163	175	187
3	10	16	28	40	52	64	76	88	100	112	124	136	148	160	172	184
4	10	17	29	41	53	65	77	89	101	113	125	137	149	161	173	185
5	10	19	33	47	60	73	87	101	114	127	141	155	168	181	195	209
6	10	22	37	52	67	82	97	112	127	142	157	172	187	202	217	232
3	14	19	34	49	64	79	94	109	124	139	154	169	184	199	214	229
4	14	21	37	53	69	85	101	117	133	149	165	181	197	213	229	245
5	14	23	40	57	74	91	108	125	142	159	176	193	210	227	244	261
6	14	25	43	61	79	97	115	133	151	169	187	205	223	241	259	277
2 SETS OF FORMS																
3	6	8	12	16	20	24	28	32	36	40	44	48	52	56	60	64
4	7	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80
5	9	12	18	24	30	36	42	48	54	60	66	72	78	84	90	96
6	9	14	21	28	35	42	49	56	63	70	77	84	91	98	105	112

struction time for 8 floors, working five days per week, will be 76 days.

With the same 5-day forming schedule but with a one-day strength-gaining period, the 76 days is reduced to 48, saving 28 days. The same number of days can be saved, in this instance, by using 9-day concrete with an extra set of forms.

Then come these questions:

How much is 28 days worth? What will it cost to save that much time? Which is cheaper, early strength concrete, or an extra form set? Answers are readily obtained by comparing the overall cost of Time, Forms and Cement.

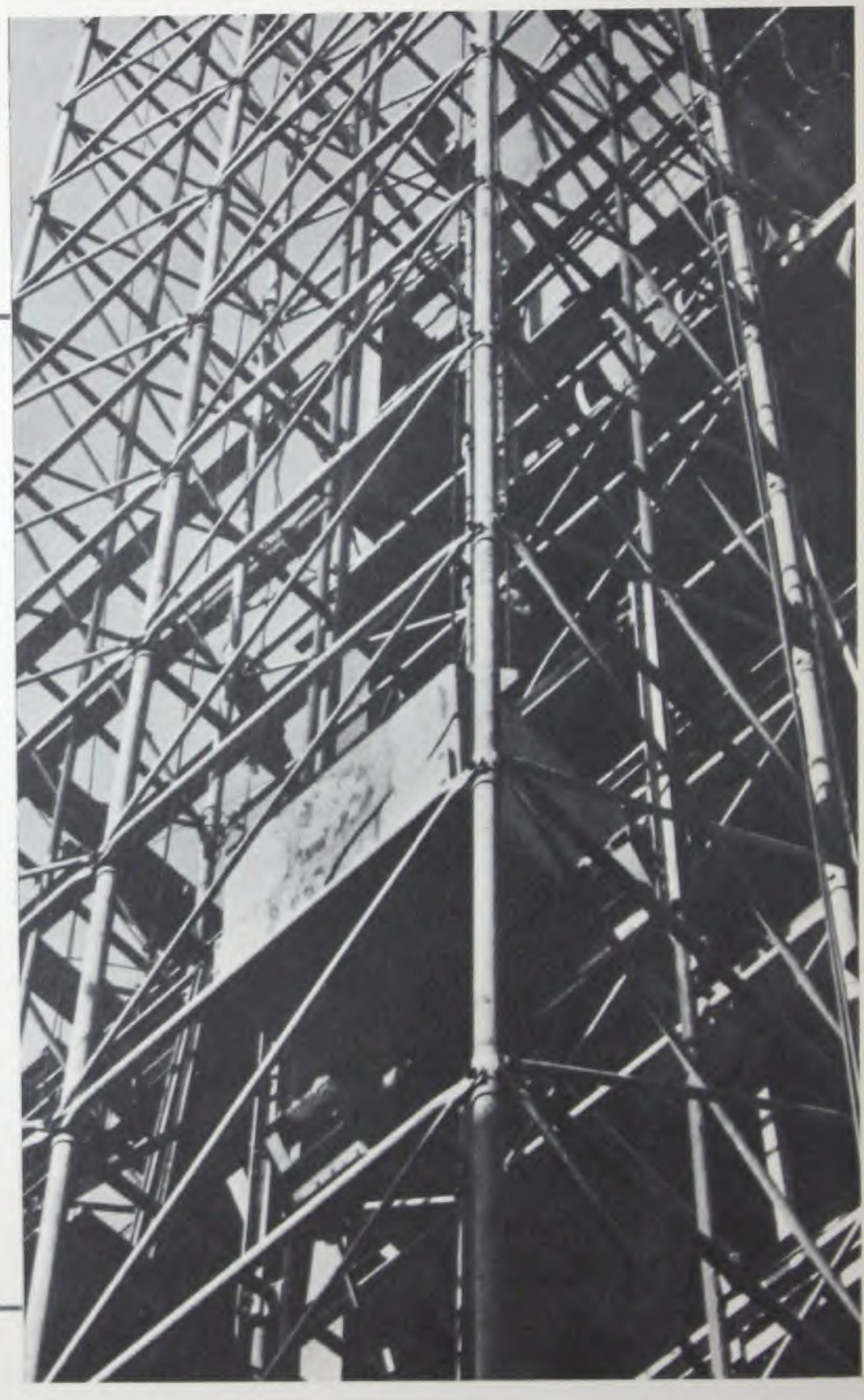
Time Costs, often under-estimated in figuring a job, are made up of general overhead, job overhead and equipment charges. These costs, which the contractor pays whether he figures them or not, usually exceed $50 a day even on small jobs, and range from $100 to $200 a day on jobs of moderate size. They are called Time Costs, because the total of these fixed daily charges depends upon the time it takes to finish a given job; the longer the time, the higher the total Time Cost or overhead.

COMPARE OVERALL COST OF TIME, FORMS AND CEMENT

Substantial savings are often realized by approaching each job from this standpoint, so let us consider each of these cost items in turn.

1. TIME COSTS:

Time costs, often under-estimated in figur-



ing a job, are so called, because the total of these cost items charged against each job depends upon the time it takes to finish that job; the longer the time, the higher the Time Cost or overhead. Time costs are made up of: (a) General Overhead, (b) Job Overhead, and (c) Equipment Charges.

(a) GENERAL OVERHEAD:

General Overhead includes the value of the contractor's own time, plus general office expense—rent, light, heat, salaries, etc. These charges, without counting taxes and insurance, amount to at least $25 a day, and may run from $50 to $100 a day or more.

General Overhead runs on from week to week and month to month; the sooner a job is completed, the lower the proportion of general overhead charged against it, and the greater the opportunity to increase the annual volume of work over which to spread it.

(b) JOB OVERHEAD

Job Overhead is made up of pay-

Form costs are made up of material and bench labor; labor removing and re-erecting; carpenter work reshaping and repairing form units. Well-built units are a sound economy, because they can be re-used oftener, and with lower handling and repair costs. A form set costing $2200 may provide only 3 or 4 uses, at a prorated cost of say $600 per floor; while a similar set of forms, built for 6 or 8 uses, may cost but $2500, and give a per-floor cost of $350. In addition, handling and repair costs are usually less for the well-built set.

roll charges and expenses, including superintendent, timekeeper and watchman; it averages between $20 and $30 a day. In some localities, various foremen and skilled workers are also carried on straight time; this may mean as much as $65 a day or more.

So, job overhead ranges from $30 to $100 a day, on buildings of moderate size. In addition, there are job-office and other charges, including liability.

These costs run on for the duration of the job; the sooner the work is completed, the lower the job overhead charges against it.

(c) EQUIPMENT COSTS:

Equipment Costs are a daily charge against the job, whether the contractor owns the equipment or rents it. If concrete is placed every week, instead of every other week, the pro rata equipment cost in a cubic yard of concrete is cut in half.

TOTAL TIME COSTS:

Here, then, are three kinds of overhead costs, the total of which depends upon the time it takes to finish a job. If all these costs are figured (and the contractor pays them, whether he figures them or not), these overhead or time charges usually exceed $50 a day even on a small job; on a moderate-sized job, they run from $100 to $200, and on larger jobs in proportion.

If these costs amount to only $50 a day, and it takes 76 working days to concrete an 8-story frame, then overhead or time charges against the job amount to $3800. If sound planning can eliminate 28 days, time costs are reduced by $1400.

2. FORM COSTS:

Form Costs are made up of material and labor required to build forms; labor removing and re-erecting forms; carpenter work reshaping and repairing form units.

Forms are made for just one purpose, to hold "wet" concrete—that is, to act as a mold until the concrete hardens sufficiently to retain its shape. Hence, the investment in forms is productive only during the first few hours after concrete is placed.

Ideally, therefore, forms should be removed the next morning after concreting; the nearer this ideal is approached in practice, the larger the profit earned by an investment in forms.

But early form removal depends upon the kind and amount of cement used, which brings us to the third cost factor—total cement cost.

Both time and form costs are minimized if forms are removed the first morning after concrete is placed. But early form removal depends upon the type and quantity of cement used. Which introduces a third factor—total cement cost. So the problem of finding the cheapest erection schedule comes down to this: what kind of concrete will produce the lowest overall cost, taking all three cost factors—time, forms and cement—into consideration.

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3. CEMENT COST:

Cement Cost depends upon how much cement is used in the mix, and upon the type of cement selected. With a small amount of water, say 5 gal. per bag of cement, the concrete has high strength, particularly at early periods, but over 7 bags of cement per cu. yd. are needed to produce the desired workability. On the other hand, with 8 gal. of water per bag of cement, early strengths will be low, but only 5 bags of cement per cu. yd. are needed to provide the required workability.

Then, there are the two types of cement: Lone Star Cement, which gains strength at a moderate rate, and 'Incor' 24-Hour Cement, which produces high strength at early periods but has a higher first cost than Lone Star.

So the problem comes down to this: What kind of concrete will produce the lowest overall cost of Time, Forms and Cement?

AGE STRENGTH CURVES FOR LONE STAR AND 'INCOR'

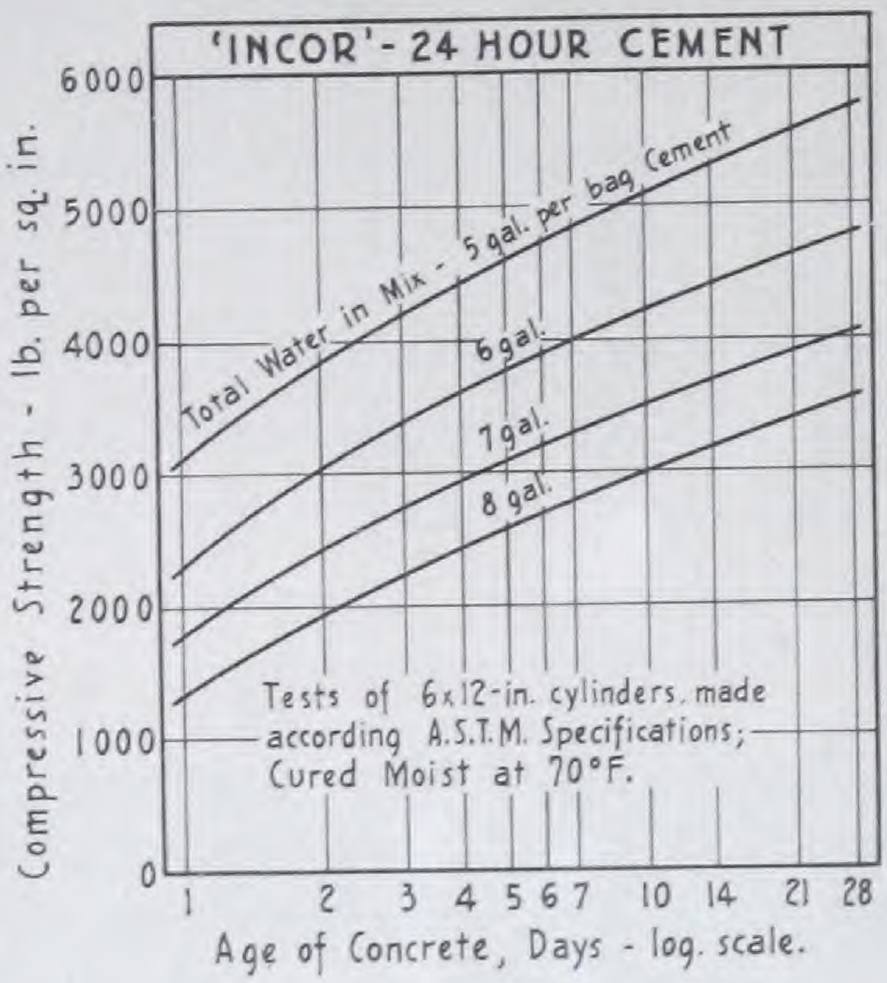


FIGURE 1:

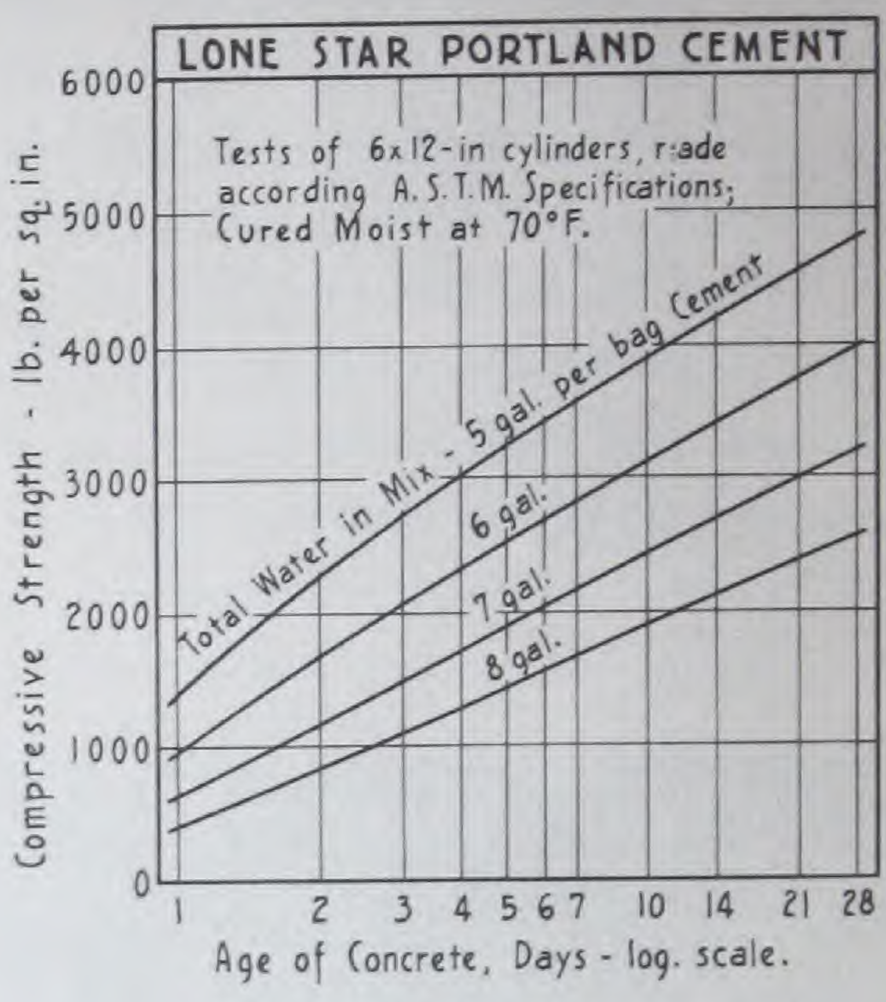


FIGURE 2:

How the Amount of Water Affects Concrete Strength at Ages up to 28 Days, for both Lone Star and 'Incor' Cements.

To find the relation between strength and quantity of mixing water at any age, enter either Lone Star or 'Incor' diagram with two known factors and find the third or unknown value, thus:

(1) Find the water content that results in 2000 lb. concrete at 2 days. Using 'Incor,' start at 2000 lb. at the left and move towards the right until the 2 day vertical line is reached. The 8 gal. inclined line passes close to this point so use 8 gal. per sack of cement. With Lone Star, the 2000 lb. and the 2 day lines intersect midway between the 5 gal. and the 6 gal. inclined lines. Use 5½ gallons.

(2) When will 6½ gal. concrete develop 2000 lb.? Enter the Lone Star diagram at the left and move upwards towards the right midway between the 6 gal. and 7 gal. lines until the horizontal 2000 lb. line is reached at 4 days. In like manner, it is found that 2000 lb. is obtained with 'Incor' in one day.

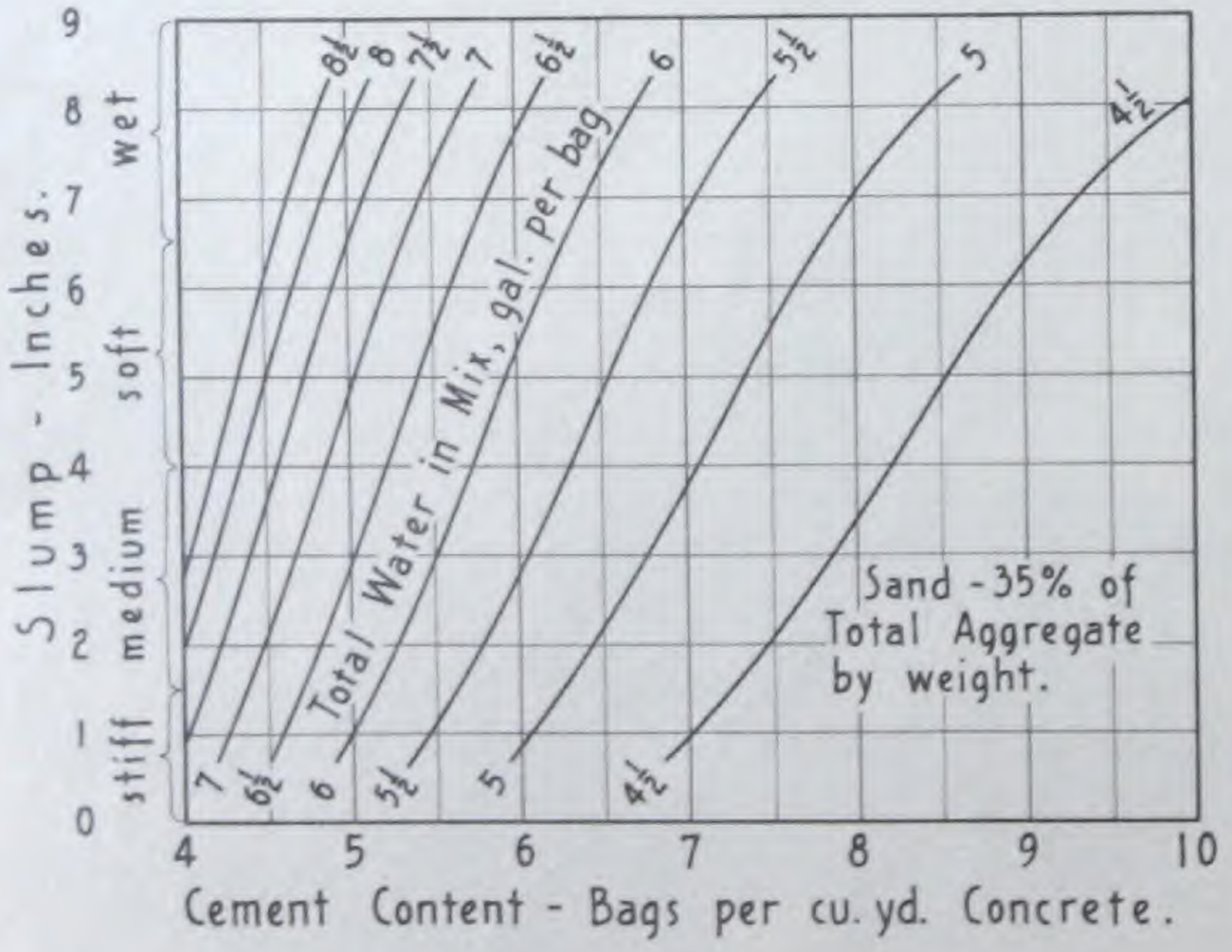


FIGURE 3:

How the Amount of Water and Cement Affects Workability.

To find the relation between cement, water and slump, enter the diagram with two known properties and find the third or unknown thus:

(1) Given a 3″ slump, 6½ gal. of water per sack of cement, find the cement content. Move right on 3″ slump line till 6½ gal. line is reached and read 5 bags of cement per cubic yard at bottom of diagram.

(2) Given a 5″ slump, 6½ bags of cement per cubic yard, find water content. Move right on 5″ slump line until 6½ bag vertical line is reached; 5½ gal. line crosses at this point.

(3) Given a 5.5 bag concrete, 6¾ gal. of water (6¾ gal. is midway between the 7 gal. and 6½ gal. lines). Find the slump. Move upward along 5.5 bag line until midway between 6½ gal. and 7 gal. line—result 6″ slump.

Figuring the Low-Cost Schedule

A METHOD for finding the lowest overall cost of time, forms and cement is outlined below, using as an example a typical concrete frame structure, as per following job data:

Plan: 80′ × 125′ = 10,000 sq. ft.

Height: 6 stories and roof = 7 floors.

Superstructure Concrete: 1400 cu. yd.

Design of Concrete: Not more than 7½ gal. of water per bag of cement nor less than 5 bags of cement per cubic yard of concrete.

Form Removal: After concrete has a compressive strength of 2000 lb. per sq. in.

Time Cost: Fixed and job overhead plus equipment charges, $100 per day.

Cement Cost: Lone Star Cement, $2.00 per bbl. 'Incor' 24-Hour Cement, $2.50 per bbl.

Cost of Forms: One floor of forms	$2500
Two floors of shores	1200
Cost one form set	$3700
Two floors of forms	$5000
3½ floors of shores	2100
Cost two form sets	$7100

Construction Schedule: 5 day work week. For each floor: 6 days to strip and reassemble forms, place steel and set conduits. 1 day to pour concrete. Form removal based on concrete strength.

This is not a "rush" job, so the number of days required to erect the frame is up to the contractor. Form costs are given for both one and two form sets; per-barrel cement costs are shown; but the kind of concrete, and hence the total cement cost, can be varied.

It will also be noted that daily time costs, form assembly and concreting time are fixed by job conditions; but the length of the strength-gaining period can be increased or decreased, depending upon the amount and the type of cement used. Since the forming and concreting periods are inflexible, the time required to erect the frame will increase or decrease as the strength-gaining period becomes longer or shorter. A shorter strength-gaining period decreases the time cost but also increases the cement cost; so again we have the question, what cement cost will produce the lowest total cost of time, forms and cement?

First, Find the Cement Cost: Cement cost varies with the kind and the quantity of cement used. But both kind and quantity depend upon how soon the required strength of 2000 lb. per square inch is developed.

The strength of the concrete is also affected by the quantity of water used; as the water increases, the strength decreases. So it is necessary first to find how much water should be used in order to obtain 2000 lb. concrete at periods ranging from one to seven days.

Figure 1 shows that with 'Incor' 24-Hour Cement, 2000 lb. strength is secured at one day with 6½ gal. of water per bag of cement, and at less than two days with 7½ gal. (the maximum permitted by this specification).

Figure 2 shows that Lone Star develops 2000 lb. at 3 days using 6 gal., 4 days with 6½ gal., 5 days with 6¾ gal., 6 days with 7 gal., and

Table III

Days for 2000 lb. per sq. in.	Kind of Cement	Gals. of Water per Bag of Cement	Cement Bags per cu. yd.	Cement Cost per cu. yd.	Cement Cost for 1400 cu. yd.
1	'Incor'	6½	5.6	$3.50	$4900
2	'Incor'	7½	5.0	3.13	4382
3	Lone Star	6	6.2	3.10	4340
4	Lone Star	6½	5.6	2.80	3920
5	Lone Star	6¾	5.4	2.70	3780
6	Lone Star	7	5.2	2.60	3640
7	Lone Star	7½	5.0	2.50	3500

7 days with 7½ gal. These water contents are entered in Table III, Column 3.

This fixes the amount of water per bag of cement, but the amount of cement in each case will depend upon the desired concrete workability. Let us assume that a 6-inch slump concrete will have the proper workability for this job, and determine from Figure 3 the number of bags of cement which should be used with each water content.

Using 6½ gal. water and 6-inch slump, 5.6 bags of cement per cubic yard are needed; 7½ gal., 4.9 bags. But the minimum cement content specified is 5 bags, so this figure is entered in Table III, Column 4. In the same way, cement quantities corresponding to the remaining water contents are ascertained and recorded in Table III. Cement quantities per cubic yard shown in Column 4 are then multiplied by the cement price per barrel and the resulting cement costs per cubic yard are recorded in Column 5.

There are 1400 cubic yards of concrete in the building, so each cement cost for one cubic yard as given in Column 5 is multiplied by 1400 to obtain the corresponding total cement cost shown in Column 6.

Second, Calculate Time Cost: Next step is to ascertain the effect of these seven strength-gaining periods on the total time required to erect the building frame. Table I (page 7) shows that for 6-day forming and one day form removal, 49 days are needed to complete seven floors; 2-day form removal, 52 days. The remaining erection times are similarly determined and entered in Table IV. Then, on the line below erection time, is recorded the corresponding time cost at $100 per day.

Third, Form and Cement Costs: Form costs as shown by job data on page 13, are then entered in Table IV. And, finally, cement costs, as given in Table III, Column 6, are entered.

Using Two Form Sets: Here, the same procedure is followed: In Table I, we find that frame erection with two form sets requires 49 days, which is $4900 in time costs. Two form sets cost $7100. As forms need not be removed for 10 days, the minimum cement content of 5

Table IV

	One Form Set							Two Form Sets
Form Removal—Days	1	2	3	4	5	6	7	9
Erection Time—Days	49	52	57	67	67	67	73	49
Time Cost	$ 4,900	$ 5,200	$ 5,700	$ 6,700	$ 6,700	$ 6,700	$ 7,300	$ 4,900
Form Cost	3,700	3,700	3,700	3,700	3,700	3,700	3,700	7,100
Cement Cost	4,900	4,382	4,340	3,920	3,780	3,640	3,500	3,500
Total	$13,500	$13,282	$13,740	$14,320	$14,180	$14,040	$14,500	$15,500

Table V		
	Lone Star	'Incor'
Form Removal—Days	5	1
Erection Time—Days	67	49
Time Cost	$6,700	$4,900
Form Cost	3,700	3,700
Cement Cost	3,780	4,725
Total	$14,180	$13,325

bags of Lone Star per cubic yard will suffice. This results in a cement cost of $3500.

Finally, Compare Overall Costs: Adding up the eight columns in Table IV, we find that the total cost of time, forms and cement decreases as the time of erection is shortened. The two 'Incor' schedules have a lower cost than any of the Lone Star schedules, proving that money is saved by eliminating needless time in the strength-gaining period. Of course, as the value of time is increased or decreased, other schedules may be more economical. Thus, in this instance, if time costs more than $180 a day, the erection schedule with one-day form removal becomes cheapest. On the other hand, if time is worth only $45 a day, the 6-day form-removal schedule is cheapest. Similarly, any set of conditions can readily be reduced to a simple comparison indicating which erection schedule shows the lowest overall cost of time, forms and cement.

WHEN MIX IS SPECIFIED

The foregoing example assumes a specification permitting the design of the concrete mix, so that maximum economy can be secured in both time and cement costs. Frequently, however, it is not possible to design the concrete, because proportions are already fixed by specification.

Take a job where a mix is specified which establishes the cement content at 5.4 bags per cubic yard, (the usual 1—2—4 mix); all other conditions being the same as in the previous example. With cement content fixed, it is necessary to find the amount of water per bag of cement that will produce a 6-inch slump concrete; and then determine the effect upon the strength-gaining period and upon total time costs.

From Figure 3 we find that a 5.4 bag mix requires 6¾ gal. of water per bag of cement for a 6-inch slump; from Figure 1, that a 6¾ gal. 'Incor' concrete will develop 1950 lb. in 24 hours; and from Figure 2, that a similar Lone Star concrete will develop 2000 lb. within 5 days.

Table I shows that 49 days are needed to erect the building frame using 'Incor', and 67 days with Lone Star. Time, form and cement costs are entered in Table V. A comparison of costs, as shown in this Table, indicates that under the given conditions 'Incor' again shows an overall saving, in this case, $855. Comparison with Table IV indicates that the cost of a second form set is higher than either the Lone Star or 'Incor' schedules.

Here again it is seen that the erection schedule making the best use of time results in the lowest erection cost.

The principles involved in this and the preceding example apply to all types of concrete buildings, large and small; although cost relationships will of course vary with job conditions. With this method, it is easily possible to find out in advance the most economical erection schedule, as illustrated by the typical jobs described on the following pages.

This method points the way to increased profits by reducing costs; and that is the primary object of every sound business enterprise.

Six Typical Jobs

SHOW NET SAVINGS OF 38¢ TO $1.49 A CU. YD. OF CONCRETE

HOW this cost-comparison method has worked out in practice is illustrated by six buildings recently constructed in different parts of the country. These jobs include industrial, business, institutional and apartment structures—of concrete frame, steel frame and wall-bearing construction. Facts were supplied by the contractors, and are used with their permission.

1 Hospital Building, State Hospital No. 1, Fulton, Mo.— B. D. Simons, *Contractor*

Concrete skeleton frame; 5 floors and roof; simple rectangular plan . . . 1070 cu. yd. superstructure concrete.

Form Removal: Specified, 10 days using Lone Star Cement, 3 days using 'Incor.'

Form Cost: $937 a set.

Time Cost: $28.50 per day for job overhead.

Construction Schedule: 6-day work week; 5 days to strip and re-assemble forms, place steel and set conduits; one day to pour concrete.

Mr. Simons figured the job for 10-day form removal, with both one and two form sets, and for 3-day form removal, using 'Incor' with one form set. As a result, he used 'Incor' and one form set for all superstructure concrete, saving 30 days, and enabling him to get the frame up before heavy winter weather set in.

COMPARATIVE COST SUMMARY			
Cost Factors	10-Day Form Removal		3-Day Form Removal With One Form Set
	With One Form Set	With Two Form Sets	
Total Erection Time—Days	78	41	48
Time Cost @ $28.50 . . .	$2223	$1169	$1368
Forms @ $937 a set . . .	937	1874	937
Cement Cost	3120	3120	3280
Totals	$6280	$6163	$5585

'Incor' saved $578, or 54¢ a cu. yd.

2 Royal York Apartments, Columbus, Ohio

Nelson-Pedley Co., ***General Contractor***
R. L. Wirtz, ***Concrete and Brick Contractor***

Concrete skeleton frame; 6 floors, roof and penthouse; "U" shaped plan, around three sides of court . . . 2000 cu. yd. superstructure concrete.

Form Removal: 7 days using Lone Star Cement, 1 day using 'Incor'.

Form Cost: 2 floors of forms, 3 sets of shores—$7000; with 'Incor', 1 floor of forms, 2 sets of shores—$4200.

Time Cost: $46.50 per day, sub-contractor's overhead only.

Construction Schedule: 7-day week; 7 days to strip and re-assemble forms, place steel and set conduits.

Mr. Wirtz figured the job three ways—7-day form removal, first with one form set, then with two form sets; and one-day form removal using 'Incor' and one form set. One-day form removal with 'Incor' and one form set cost $900 less than the next cheapest schedule.

By working 7 days a week and pouring a floor a week, Mr. Wirtz got the job enclosed before heavy weather set in, saving heating expense on both concrete and brick work. He advanced erection time by 1½ months, the value of that time to the owner being $10,500; he also saved the general contractor 6 weeks' overhead.

COMPARATIVE COST SUMMARY			
Cost Factors	7-Day Form Removal		1-Day Form Removal With One Form Set
	With One Form Set	With Two Form Sets	
Total Erection Time—Days	100	58	58
Time Cost @ $46.50	$4650	$2700	2700
Forms	4200	7000	4200
Cement Cost	4200	4200	5250
Totals	$13,050	$13,900	$12,150

'Incor' saved $900, or 45¢ a cu. yd.

3 Popham Hall Apartments, Scarsdale, N. Y.

Willcox Construction Co., *Contractor*

Concrete skeleton frame; 6 floors, roof and penthouse; 2270 cu. yd. superstructure concrete.

Form Removal: Permitted in 3 days, using Lone Star; 1 day using 'Incor'.

Form Cost: $6000 with 'Incor'; $9000 with Lone Star.

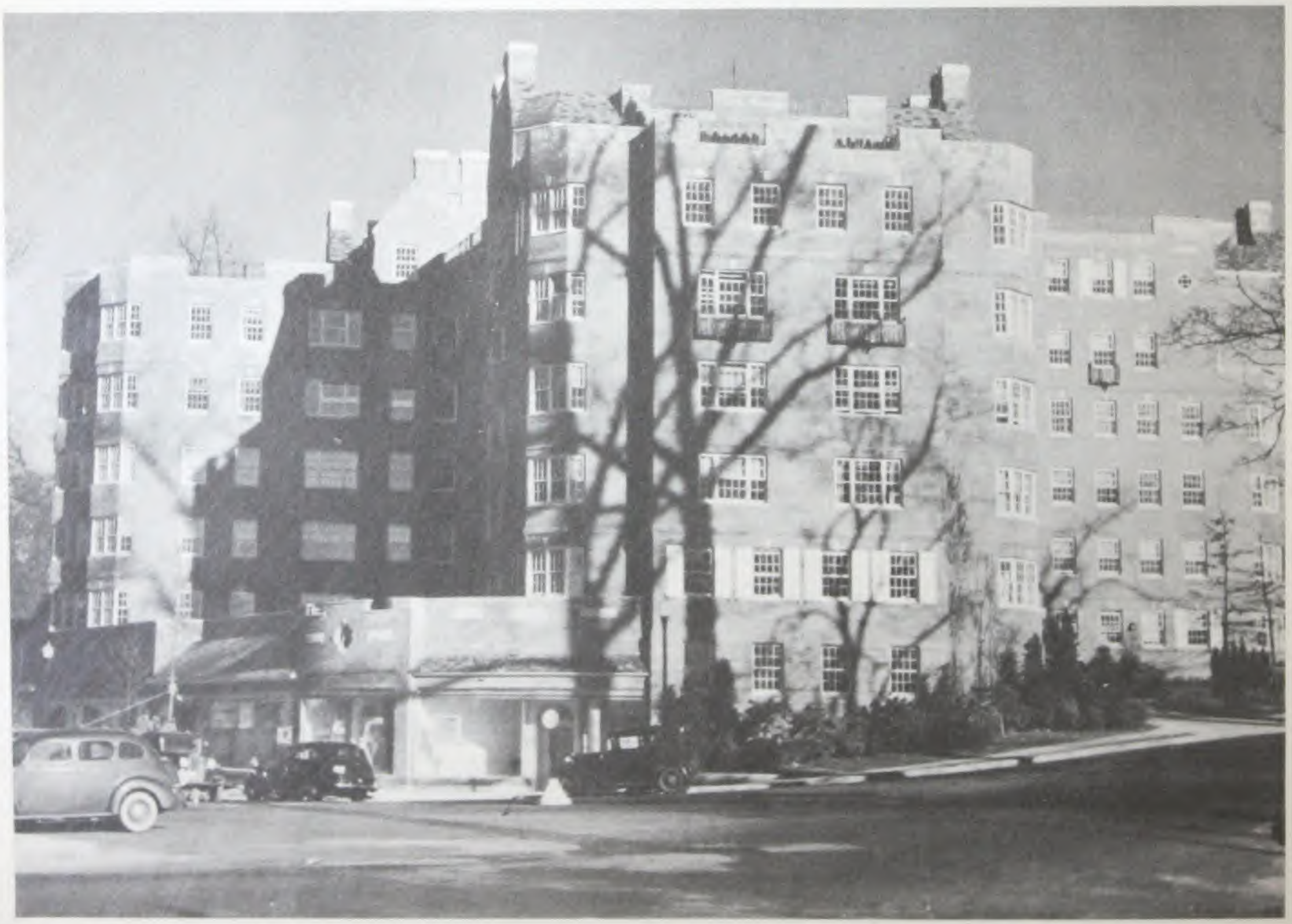
Time Cost: $167 a day for general overhead, job overhead and equipment charges.

Construction Schedule: 5-day week; 4 days to strip and re-assemble forms, place steel and conduits; one day to pour concrete.

On this job, the contractor was working against time; the apartment house had to be ready for October 1st occupancy. He estimated the job using Lone Star with 3-day form removal. In order to maintain this schedule, 50% additional forms valued at $3000 were considered, due to the necessity of leaving the forms on certain long-span sections in place longer than 3 days. He also figured the job with 'Incor' and one-day form removal. The 'Incor' schedule proved to be both faster and cheaper, enabling the contractor to promote the owner's interests through earlier completion and lower construction costs. Work on the frame began June 15; roof was poured on August 3rd.

COMPARATIVE COST SUMMARY		
Cost Factors	3-Day Form Removal with Lone Star	1-Day Form Removal with 'Incor'
Total Erection Time—Days	45	38
Time Cost @ $167	$7515	$6346
Forms	9000	6000
Cement Cost	6560	7440
Totals	$23,075	$19,786

'Incor' saved $3289, or $1.45 a cu. yd.



The same kind of savings are possible on wall-bearing jobs, except where it takes longer to run up brick work than it does to cure concrete, strip and re-assemble forms. A typical wall-bearing job follows:

4 Psychiatric Clinic Building, State Hospital No. 1, Fulton, Mo.— B. D. Simons, *Contractor*

Brick-bearing walls; 3 floors and roof, resembling a spread "U" in plan; 2160 cu. yd. superstructure concrete.

Form Removal: Specified, 10 days using Lone Star Cement, 3 days using 'Incor'.

Form Cost: $1540.

Time Cost: $37.75 per day for job overhead.

Construction Schedule: 6-day work week; each floor formed and poured in 3 sections; after pouring a section, brick work was run up to next floor; on each section, 5 days required to strip and reassemble forms, place steel and set conduits, one day to pour concrete.

On this job, Mr. Simons, who was also the contractor on the State Hospital job previously mentioned, compared the cost of 10-day form removal against 3-day form removal with 'Incor'; form costs were the same in both cases. The following cost comparison shows that in this instance 'Incor' and 3-day form removal was the low-cost schedule:

COMPARATIVE COST SUMMARY		
Cost Factors	10-Day Form Removal	3-Day Form Removal
Total Erection Time—Days	79	49
Time Cost @ $37.75 a Day	$2980	$1850
Forms	1540	1540
Cement Cost	6521	6825
Totals	$11,041	$10,215

'Incor' saved $826, or 38¢ a cu. yd.

Substantial savings are also obtained in steel-frame structures, as indicated by the following examples:

5 Coca Cola Bottling Works, Washington, D.C.
Davis & Platt, *General Contractor*
E. W. Kryz, *Concrete Contractor*

Steel-frame plant addition; 2 floors and roof; 700 cu. yd. concrete in floor slabs and fire-proofing.

Form Removal: Permitted in 7 days using Lone Star Cement; 1 day using 'Incor'.

Form Cost: $900 per set.

Time Cost: $32.50 per day for job overhead and equipment charges.

This was a rush job, the additional space being needed in order to expand mid-summer production of bottled Coca Cola. Mr. Kryz estimated three concreting schedules; 7-day form removal and one form set took too long; 'Incor' with one form set and 1-day form removal was cheaper than 7-day form removal with two form sets, and that is the way the job was built.

COMPARATIVE COST SUMMARY		
Cost Factors	7-Day Form Removal With Two Form Sets	1-Day Form Removal With One Form Set
Total Erection Time—Days	15	15
Time Cost @ $32.50 a Day	$ 488	$488
Forms	1800	900
Cement Cost	2100	2625
Totals	$4,388	$4,013

'Incor' saved $375, or 53¢ a cu. yd.

In cold weather, early service strength has added value, as illustrated by the following job:

6 New England Power Co. Bldg., Boston, Mass.
T. A. Pearson Associates, *General Contractor*
Scully Company, *Concrete Contractor*

Steel frame; 11 stories and roof; 3120 cu. yd. superstructure concrete.

Heat Protection: 3 days using Lone Star; 2 days using 'Incor' 24-Hour Cement.

Form Cost: $2500 per set.

Heat-Protection Cost: Fuel, $33.60 per day; labor tending fires, $34.10 per day; total, $67.70 per day.

Time Cost: $162 per day overhead.

Construction schedule: 5-day week; concrete placed 3 days a week, half a floor at a time; 1½ floors a week; 6 days to strip and re-assemble each form set, place steel and set conduits; one day to each pour.

On this job, the Scully Company figured two erection schedules; 3-day heat curing and four form sets, against 2-day heat curing with 'Incor' and three form sets. The 'Incor' schedule was used, and resulted in a net saving of $4654, or $1.49 a cu. yd. of concrete.

Concrete work started December 15th, was finished before February 1st—better than 1½

floors a week; concrete was run only two floors behind riveting gangs all the way up the building. Finishing operations were quickly and easily performed, despite adverse weather conditions. A clear-cut example of the all-around advantages of scheduling a job to make the best use of time.

* * *

Here, then, are six building jobs, fairly representative of the various types of concrete construction, each showing the practical advantages of estimating in advance the erection schedule which produces the lowest overall cost of time, forms and cement. Net savings ranging from 38¢ to $1.49 a cu. yd. of concrete suggest that this method is well worth considering.

COMPARATIVE COST SUMMARY		
Cost Factors	3-Day Heat Curing With 4 Form Sets	2-Day Heat Curing With 3 Form Sets
Total Erection Time—Days	47	32
Time Cost @ $162	$7614	$5184
Forms	10,000	7500
Heat Protection	4874	3250
Cement Cost	7600	9500
Totals	$30,088	$25,434

'Incor' saved $4654, or $1.49 a cu. yd.

Notes on Job Planning

IN order to get the lowest form cost per floor or per cubic yard of concrete, the most should be made of every opportunity for form re-use. Many buildings do not have typical floors all the way up, but duplication of plan usually occurs in certain floors or parts of floors. Hotels and apartment houses, for example, have several lower floors cut up by lobbies, dining, service and meeting rooms, but the upper floors are usually typical.

Then there are buildings with typical wings where forms can be re-used by staggered construction or by moving forms horizontally. In this way, forms can often be re-used on broad, low buildings which are symmetrical about the center line.

WELL-BUILT FORMS PAY

Even in non-typical buildings, there are instances where forms can be designed so as to make possible frequent re-use; in such cases, standard form units can be made of such sizes that various combinations of units will meet practically any dimension in a building. Such a solution calls for ingenuity and carefully regulated job procedure, but the savings are usually well worth the effort.

Flimsy form units or those which require extensive repairs after removal and before re-use, have a lower first cost but are expensive in the end. Sturdy, well-made units, designed to strip without damage and withstand rough handling, are a good investment.

Well-designed concrete made with Lone Star or 'Incor' holds together and places easily with minimum separation, producing dense, uniform concrete. Both Lone Star and 'Incor' produce concrete of the same high strength and durability. While 'Incor' hardens rapidly, it too allows ample time for mixing, placing and finishing.

Thus, a set of forms costing $2200 may provide only 3 or 4 uses, at a prorated cost of, say, $600 per floor; while a similar form set, good for 6 or 8 uses, may cost but $2500, or a per-floor cost of $350. In addition, handling and repair costs are usually lower for the well built set.

The kind of building and the surface finish required in effect determines the number of re-uses that can be obtained without excessive rebuilding. In an apartment house, for example, if ceilings are to be plastered, a rough surface finish is permissible, and forms can be re-used oftener than in a similar structure where ceilings are to be painted directly on the concrete.

BUILDING "MAKE-READY"

It also pays to consider the most efficient method of scheduling the "make-ready" operations —that is, the work which has to be done before concrete can be poured. Sometimes, as in a warehouse, it is merely a case of erecting simple forms and placing re-inforcement. Again as in hotels, hospitals or apartment buildings, with a lot of equipment, inserts, wiring and plumbing to be accurately set, more time is required.

Here, too, the element of time or overhead expense enters. It may, for example, pay to put

SCHEDULE No. 1 — **CEMENT LONE STAR**

Work Week . . . . . 5 days
Number of Form Sets 1
Forms—Stripping, Assembly, Steel Setting . . . . . 6 days
Forms—Removal after Concrete Placed . . . . . 6 days

Mon	Tue	Wed	Thu	Fri	Sat	Sun
1 S	2 S	3 S	4 S	5 S	6 —	7 —
8 S	9 P_1	10 C	11 C	12 C	13 C	14 C
15 S	16 S	17 S	18 S	19 S	20 —	21 —
22 S	23 P_2	24 C	25 C	26 C	27 C	28 C
29 S	30 S	31 S	32 S	33 S	34 —	35 —
36 S	37 P_3	38 C	39 C	40 C	41 C	42 C
43 S	44 S	45 S	46 S	47 S	48 —	49 —
50 S	51 P_4	52 C	53 C	54 C	55 C	56 C
57 S	58 S	59 S	60 S	61 S	62 —	63 —
64 S	65 P_5	66 C	67 C	68 C	69 C	70 C
71 S	72 S	73 S	74 S	75 S	76 —	77 —
78 S	79 P_6	80 C	81 C	82 C	83 C	84 C
85 S	86 S	87 S	88 S	89 S	90	91
92 S	93 P_7	94	95	96	97	98
99	100	101	102	103	104	105
106	107	108	109	110	111	112
113	114	115	116	117	118	119

Working Time . . . . 67 days Elapsed Time . . . . 93 days

SCHEDULE No. 2 — **CEMENT 'INCOR'**

Work Week . . . . . 5 days
Number of Form Sets 1
Forms—Stripping, Assembly, Steel Setting . . . . . 6 days
Forms—Removal after Concrete Placed . . . . . 1 day

Mon	Tue	Wed	Thu	Fri	Sat	Sun
1 S	2 S	3 S	4 S	5 S	6 —	7 —
8 S	9 P_1	10 S	11 S	12 S	13 —	14 —
15 S	16 S	17 S	18 P_2	19 S	20 —	21 —
22 S	23 S	24 S	25 S	26 S	27 —	28 —
29 P_3	30 S	31 S	32 S	33 S	34 —	35 —
36 S	37 S	38 P_4	39 S	40 S	41 —	42 —
43 S	44 S	45 S	46 S	47 P_5	48 —	49 —
50 S	51 S	52 S	53 S	54 S	55 —	56 —
57 S	58 P_6	59 S	60 S	61 S	62 —	63 —
64 S	65 S	66 S	67 P_7	68	69	70
71	72	73	74	75	76	77
78	79	80	81	82	83	84
85	86	87	88	89	90	91
92	93	94	95	96	97	98
99	100	101	102	103	104	105
106	107	108	109	110	111	112
113	114	115	116	117	118	119

Working Time . . . . 49 days Elapsed Time . . . . 67 days

S - Days forms are stripped and re-assembled
P - Days concrete is placed
C - Days concrete cures—that is, the strength-gaining period

FIGURE 4:

These two charts illustrate a simple way of determining the time required to erect a building frame, knowing the number of days needed on each floor to (1) strip and re-erect forms, (2) place concrete, (3) permit concrete to gain service strength.

This method was followed in preparing Tables I and II, page 7. Note that the total number of working days in the schedules are the elapsed time minus week-end days on which no work was done. Also note that total working days agree with those given in Table I for the same conditions.

on more labor to complete form assembly, say, in 4 days instead of 5, in order to save a day's overhead on each assembly. Example:

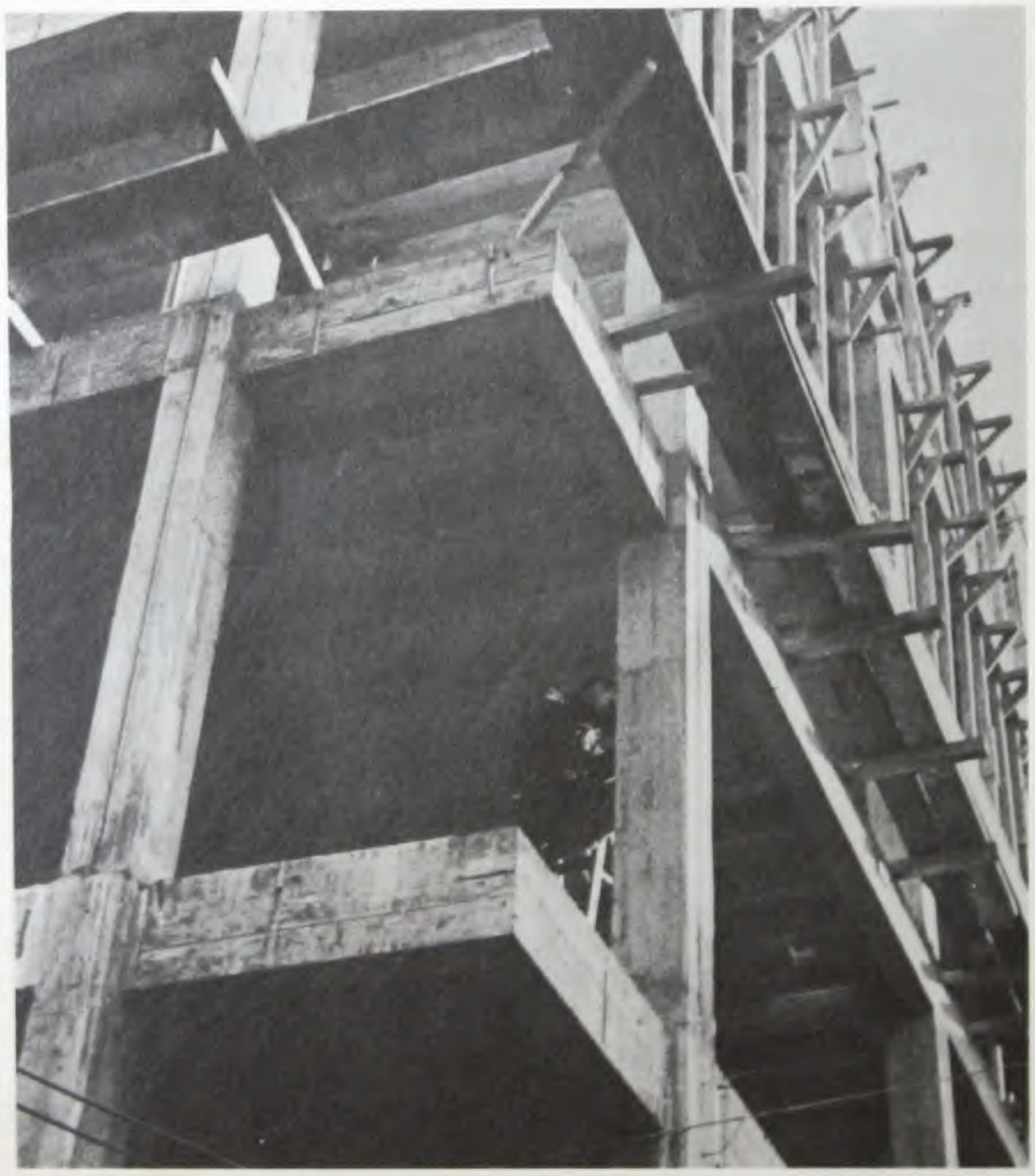
If labor for 5-day assembly costs $200 a day and overhead is $100 a day, the contractor can afford to spend up to $275 a day for labor to complete assembly in 4 days, and still break even. Anything less than $275 a day for labor to accomplish 4-day assembly is a clear saving.

SIMPLE SCHEDULE-FORM USEFUL

In estimating the lowest cost erection schedule, a form similar to that shown in Figure 4 is useful. By means of symbols for the various operations, erection time under any combination of conditions may readily be calculated. More elaborate forms are of course necessary if progress of several craftsmen, such as plasterers, bricklayers and plumbers are included.

CAREFUL PLANNING PAYS

The importance of thorough planning cannot be over-emphasized. Witness the experience of the contractors on the typical jobs previously outlined herein. By careful advance planning, these contractors saved from 38¢ to $1.49 per cubic yard of concrete, mainly because they balanced their outlay for forms and cement against the cost of time. In other words, they made each unit of time earn the maximum return. That is the essence of the problem of cutting concrete costs.



Let Economy Decide

FOR every building project, there is an erection schedule which shows the lowest overall cost of time, forms and cement. Money can usually be saved by figuring the lowest-cost schedule, using the quick, easy method outlined in this book.

In some cases, faster schedules are cheaper; in others, the reverse is true. Which means that on some jobs 'Incor'* 24-Hour Cement, which is self-supporting in one-fifth the usual time, provides maximum economies; on other jobs, Lone Star Cement is the better buy.

It pays to estimate each job carefully in advance. Then, let economy decide which of these two cements to use. You gain either way, because—Better Cement Makes Better Concrete. *Reg. U. S. Pat. Off.

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